Interactive Holographic 3D Display System

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Keywords: interactive hologram, digital holography, CGH, 3D content, SLM.

ABSTRACT

In this paper, we demonstrate that holographic 3D content of 1,024 views related with all directions of 360˚ is calculated by FFT-based CGH algorithm and is encoded by the Burkhardt encoding. We represents it onto the interactive holographic display system, which can support wide-viewing range of ±60˚ and directly interact between the user and holographic 3D scenes.

1 INTRODUCTION

Three-dimensional (3D) displays connected with the field of virtual or augmented reality have recently been subject to considerable attractive interest due to a variety of industrial opportunities supported by mobile device applications [1]. Electro-holography is a promising 3D display technology that can reconstructs the optical field of a 3D scene or object light, visualizing the most real-like 3D scene in comparison with conventional stereoscopic 3D displays. Recently, several approaches, such as aerial floating-screens and rotating-3D screen display, were introduced as 3D display systems connected with user's interaction functions, as described in references [2-4]. These systems typically have the inherent disadvantages of requiring high-speed, time-multiplexing technique, or spatial multiplexing technique, as well as accurate position-recognition, high-precision-control technique among multiple-optical components [5].

In the paper, we report on a novel implementation and demonstration of an interactive holographic 3D display system based on a single compact display module, and a set of motion/voice/haptic/sensors capable of direct interaction between a user and 360° (1,024 views) holographic 3D content. In addition, the system is fabricated to observe the optically reconstructed image of the wide viewing angle located along the position of the user's eye through the face-tracking sensor.

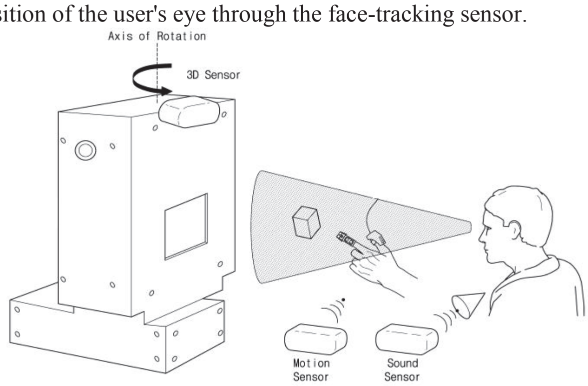

Figure 1. Schematic of the interactive holographic display.

2 EXPERIMENT AND RESULTS

The interactive holographic 3D module and the scheme of display process pipeline are shown in Figure 1 and Figure 2 respectively.

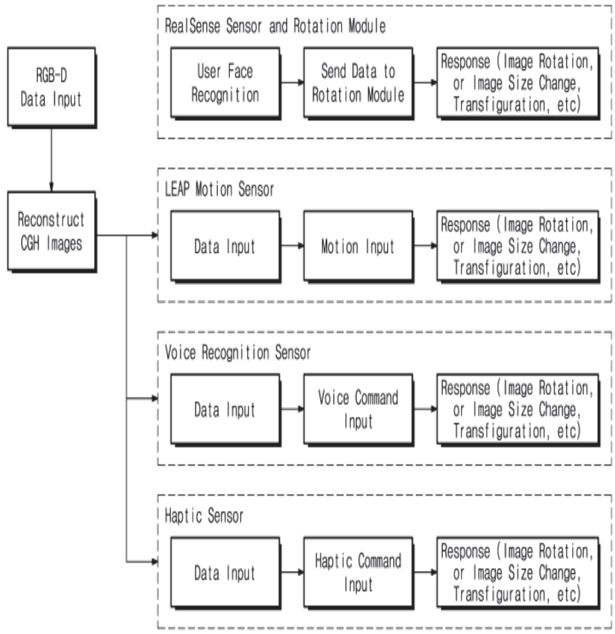

Figure 2. Pipeline of the holographic display system based on user's interactive sensing information.

We use the commercial tool Maya^{TM} SW program in order to extract 3D model's contents and to save them into RGB-depth map data for calculation of the FFT-based CGHs [6, 7]. After CGHs of 1,024 views are prepared, we adopt the Burkhardt encoding method to upload them onto an amplitude-modulating, spatial light modulator (SLM). We choose an LCD-SLM (2,560 x 1,440 pixels, diagonal size of 5.5", and grey level expression of 8 bits) as the amplitude-modulating SLM, well mounted on the rotational module [See Figure 4]. There are a pair of field lenses (focal length: 75 cm) located directly after SLM, which produce each viewing window for user to observe 3D scenes near its focal length. To minimize the thickness of the holographic display module, two transparent volume-grating-based elements, *i.e.* a reflective-typed light waveguide (VG I) and a reflection-typed light waveguide (VG II), are designed and fabricated [see Figure 3], where each dedicated VG component reaches Kogelnik's diffraction efficiency of about 95% for the wavelength of 532 nm. The two thin light-guiding plates are aligned to generate a collimated light beam from a green (532 nm) laser source (CNI optoelectronics, MGL-S-532) as the coherent uniform illumination. After reflecting vertically from VG (II), the collimated beam can be incident towards the LCD-SLM panel. Thus, the integrated compact display system is ready to operate and interact directly with the user through the holographic software pipeline of the interaction. Figure 2 indicates the block diagram that 3D content is controlled by motion sensor, haptic sensor, and sound sensor.

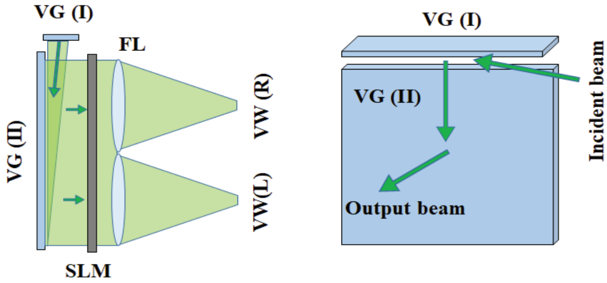

Figure 3. Configuration of the backlight unit for the holographic display module that comprises two thin backlight components, a SLM panel, and a pair of field lenses in parallel.

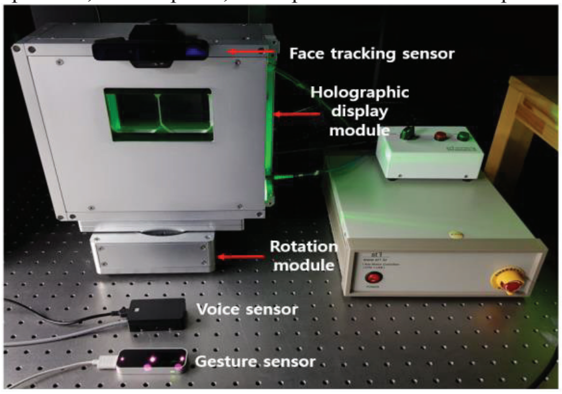

Figure 4. Experimental setup of our system.

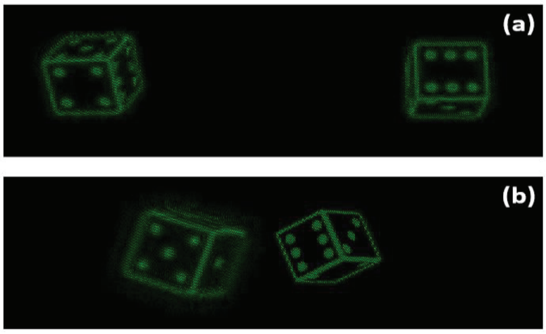

Figure 5. Objects reconstructed from CGH content.

Additionally, the rotation module can adjust the position of viewing angle so that the user can easily observe holographic 3D objects through the face-tracking sensor. We actually use the product of RealSense™ to track the user's face position and to control the rotational module in real-time, which allows the user to observe holographic 3D scene from his/her position within the maximal rotational range of ±60˚ from the front position (the rotational module has a minimal angular step of 0.352˚). Integrated system for the interactive holographic display is shown in Figure 4, which is specially built to maintain a compact, modular form factor in order to be moved off from the optical table. As shown in Figure 5, two different holographic 3D scenes among 1,024 views are illustrated. Figure 5 (a) shows that two objects are focused together. When one object is in the camera lens focus, it's photographic image is sharp, and another object out of focus is blurred as shown in Figure 5 (b), thus supporting an accommodation effect.

3 CONCLUSION

In conclusion, we demonstrate that holographic 3D content of 1,024 views related with all directions of 360˚ is generated and represents it onto our interactive holographic display system, which can support wide-viewing range of ±60˚ and directly interact between the user and real holographic 3D content. As a future study, we will optically reconstruct full-color holographic images with upgraded RGB wavelength content as well as the RGB coherent backlight unit, so that an observer may interact full color holographic content in real-time.

Acknowledgment

This work was supported by Institute for Information & communications Technology Promotion (IITP) grant funded by the Korea government (MSIP) (No. 2016-0-00010, Digital Content In-house R&D)

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